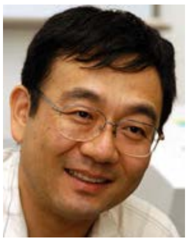
【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Mathematics/Physics)



Title of Project : Observation of supernova neutrinos with neutron tagging

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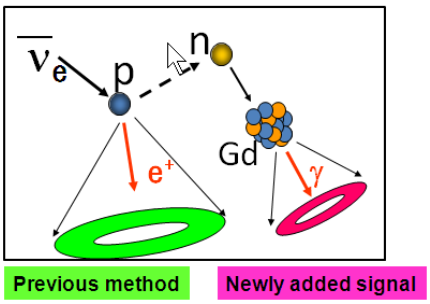
Research Project Number : 26000003 Researcher Number : 70192672
Research Area : Particle/Nuclear/Cosmic ray/Astro physics
Keyword : Cosmic ray (experiment)

【Purpose and Background of the Research】

The supernova explosion is the last phenomena of massive stars and it is triggered by a gravitational collapse of their iron cores, which results in formation of neutron stars and black holes. Huge amount of energy is produced at the time of the explosion for about 10 seconds and most of the energy is carried out by neutrinos. Actually, such neutrinos were observed by Kamiokande with the supernova SN1987A, and the basic scenario of the explosion mechanism was confirmed. However, because the number of observed neutrino events was only about ten, details of the mechanism was not clarified. Also, this was an observation of <u>one</u> supernova, and many supernovae are necessary to investigate a global picture. There are approximately 10^{20} stars in the universe, and about 0.3% of them, i.e. about 10^{17} stars have become supernovae so far. The neutrinos produced by those explosions are called supernova relic neutrinos (SRNs). The main purpose of this research is to observe SRNs. Another purpose is to determine the direction of supernova if it happens in our galaxy.

【Research Methods】

All types of neutrinos are emitted when a supernova explosion happens. Anti-electron-neutrinos are easiest to be detected and they produce positions and neutrinos with free proton interactions. In this research, we will detect the anti-electron-neutrinos with neutron tagging as shown in the left figure. It is predicted that SRNs dominate in the energy range from 10 to 30 MeV. However, a lot of solar neutrinos and spallation products of cosmic rays dominates in this energy range. That is why neutron-tagging is necessary to observe SRNs. Since the flux of SRNs is estimated to be small, a big detector like Super-Kamiokande (SK) will be necessary. In this research, we plan to put gadolinium into the SK water tank. Gadolinium has a large neutron capture cross section and emits high energy gamma rays which can be detected by SK.



If a supernova happens in our galaxy, many thousands of anti-electron-neutrino interactions and several hundred electron-scatterings happen at SK. Electron-scattering events, which have directional information, can be extracted using neutron anti-tagging and the pointing accuracy will be improved. In case of a nearby supernova such as Betelgeuse (if it happens), using anti-electron-neutrinos emitted during the silicon burning phase, a precursor of the explosion could be detected.

【Expected Research Achievements and Scientific Significance】

If this research is realized, it would be the first observation of SRNs in the world. It will reveal history of massive stars in the universe. Also, averaged neutrino energy spectrum could be observed. For the supernova in our galaxy, it is very important to dispatch the directional information to optical observatories as soon as possible. A supernova starts emitting photons when the shockwave reaches to the surface of the star, which usually takes from several hours to a day. With a quick dispatch of neutrino detection, optical observations can be started from its very early stage.

【Publications Relevant to the Project】

・"GADZOOKS! Anti-neutrino spectroscopy with large water Cherenkov detectors", J. F. Beacom, M. R. Vagins, Phys.Rev.Lett. 93 (2004) 171101.
・"Supernova Relic Neutrino Search at Super-Kamiokande", Super-Kamiokande Collaboration (K. Bays et al.), Phys.Rev. D85 (2012) 052007.

【Term of Project】 FY2014-2018

【Budget Allocation】 453,400 Thousand Yen

【Homepage Address and Other Contact Information】

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